Fault Tolerant Architecture For Quantum Dot Cellular Automata

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In the six year since Lent et al. university of Notre Dame proposed the quantum-dot cellular automaton (QCA) paradigm, experiments have borne out the feasibility of this approach for nano-electronic computing. Prototype systems based on capacitively coupled metal dots have demonstrated single-electron cell switching, transmission of a signal in a QCA "wire", and operation of a majority cell which functions as a programmable AND/OR gate. These demonstrations are all carried out in the Coulomb blockade regime, at temperatures below 70 mK. Calculations suggest that QCA cells of 1-3 nm dimensions would operate at above 300K, which suggests that we should look for molecules that can act as QCA cells.

There is, however, yet another obstacle in the needed perfection in manufacturing and tolerance to fabrication defects. In fact, it is widely believed that QCA devices and circuits are highly sensitive to imprecision in their assembly. This, in turn, has motivated the investigation of molecular self-assembly techniques. However, there are still questions as to whether molecular assemblies would give enough control over cell positioning.

In this paper, we present the design of novel universal gates, which offer remarkable fault tolerance capabilities in terms of imprecision in cells assembly and input and output as well as defective cells. These gates have been validated through simulation based on physical model. Our results indicate that, contrary to the current belief, the QCA arrays through their collective and cellular automata behavior exhibit a very high degree of fault tolerance. They also motivate a new and more detailed modeling study of collective fault tolerance behavior of arrays of QCA cells.